**REPORT FOR OBJ1.TASK 13: SPECIFIC STORM WATER CREDIT MODEL**

To: MPCA

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Re: Contract CR5332

**RECOMMENDED APPROACH FOR DETERMINING STORMWATER VOLUME CREDITS FOR TREE BMP’S**

See “Notes” below for explanation of terms.

**For a Tree BMP Without an Underdrain:**

Credit = volume of ponded water + volume of gravity water in soil + volume of ET over 3 days + volume of interception

**For a Tree BMP With an Underdrain**

While all the ponded water and gravity water in a Tree BMP without an underdrain will infiltrate into the in situ soils, for a tree BMP with an underdrain, some of the gravity and ponded water in the soil will infiltrate into in situ soils (unless the BMP has an impermeable liner), and the remainder will leave the system via an underdrain. Only the portion of the gravity and ponded water that infiltrates into in situ soils can be counted towards volume credits.

Credit = volume of gravity and ponded water that infiltrates into in situ soils + volume of ET over 3 days + volume of interception

**Notes:**

**Supporting Research**

See Task 13 “The Roles and Effects Of Tree Evapotranspiration And Canopy Interception In Stormwater Management Systems And Strategies: A Review Of Current Literature And Proposed Methodology For Quantification In The MIDS Calculator Application” for supporting research.

**Maximum Volume Credit**

For all of the formulas above, maximum volume credit possible is the volume of the performance goal.

**Gravity Water In Soil**

Gravity water in soil = volume of water in soil at soil saturation – volume of water in soil at field capacity

While all the ponded water and gravity water in a Tree BMP without an underdrain will infiltrate into the in situ soils, for a tree BMP with an underdrain, only some of the gravity and ponded water in the soil will infiltrate into in situ soil (unless the BMP has an impermeable liner), and the remainder will leave the system via an underdrain. Only the portion of the gravity and ponded water that infiltrates into in situ soils can be counted towards volume credits.

We recommend using a hydrologic performance model, such as, the North Carolina Long Term Bioretention Hydrologic Performance Tool (HyPerTool), developed by North Carolina State University Department of Biological and Agricultural Engineering, to develop a proxy for how much of the gravity and ponded water will infiltrate vs. how much will leave via the underdrain. The proxy could be developed by running multiple sample calculations, using a hydrologic performance model, for each of the Hydrologic Soil Groups, with an underdrain at the bottom and with an elevated underdrain.

**ET (Evapotranspiration)**

To estimate volume of ET per day, we recommend using the formula developed by Lindsey and Bassuk (1991).



For the purpose of the MIDS calculator, the leaf area index and canopy diameter would best be input as empirical values for the tree. The leaf area index (LAI) should be stratified by type into either 1) deciduous tree species (LAI = 4.7, or 2) evergreen tree species (5.47), per the collected research on global leaf area from 1932-2000. (Scurlock, Asner and Gower 2002)

The canopy projection area (CP) should be input by tree species for perceived tree canopy diameter at maturity as calculated by:

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*where:*

*CP = canopy projection area (ft2)*

*d = diameter of the canopy, as measured at the dripline (ft)*

Please refer to the Tree Species List in this section of the MPCA Stormwater Manual for these values for input into the MIDS calculator.

The evaporation rate (Erate) per unit time can be calculated using a pan evaporation rate for the given area, as available at NOAA. This should be estimated into *per day* value.

The evaporation ratio (Eratio) is the equivalent that accounts for the efficiency of the leaves to transpire the available soil water or, alternately, the stomatal resistance of the canopy to transpiration and water movement. This is set at 0.20, or 20% based on research by Lindsey and Bassuk (1991). This means that a cm2 of leaf transpires only about 1/5 as much as a cm2 of pan surface.

Per MPCA, it is assumed for purposes of the MIDS calculator that it rains every 3 days, so credit is given for 3 days of ET.

If plant available water is smaller than the calculated ET over 3 days, then use the plant available water.

**Interception**

For ease of MIDS credit assignment per the current Calculator, we would suggest assigning the simplified values of the interception capacity (Ic) as presented by Breuer et al. (2003) for deciduous and evergreen tree species:

Ic evergreen spp. = 0.087” (2.2mm)

Ic deciduous spp. = 0.043” (1.1mm)

**Tree Size Assumptions:**

* Provide credit for interception and ET based on tree size at maturity per tree canopy diameter in Task 3 species list IF adequate soil volume is provided.
* Minimum soil volume required is 2 cubic feet per square foot of canopy area.
* If minimum soil volume is not provided, then tree canopy area should be based on maximum size attainable assuming 1 s.f. of canopy area per 2 c.f. of rootable soil.

**Example Gravity Water, ET and Interception Calculations**

If we have 1 tree with a 30’ diameter canopy in 1400 cf of loamy sand in a tree trench without an underdrain:

1. **Gravity water**

 From Saxton and Rawls 2006:

Saturation = 46%

Field Capacity (FC) = 12 %

Wilting Point (WP)= 5%

 Saturation – Field Capacity = 34%

 1400\*0.34 = 476 c.f.

1. **ET over 3 days**

 Maximum possible ET if not irrigated = FC-WP = 12% - 5% => 0.07\*1400 c.f. = 98 c.f.

 Using Lindsey and Bassuk (1991) equation:

*Assume:*

Canopy projection (CP) = µr2

CP for 30’ diameter tree = 707 s.f.

LAI deciduous tree = 4.7

E ratio = 0.2 per Lindsey and Bassuk (1991)

 ET = 707 s.f. x 4.7 x 0.24/12 ft/day x 0.2 = 13.3 c.f./day x 3 days between storms = 39.87 c.f. per storm

 Maximum possible = 98 c.f., so use 39.87 c.f.

                             III.            **Interception**

 0.043”/12 \* 707 s.f. = 2.5 c.f.

**Requirements to Obtain Tree Volume Credit**

* Maintenance agreement must be in place.
* If a tree is removed for any reason, it must be replaced with another tree of equal or greater value and anticipated size at maturity.

**REFERENCES**

See “The Roles and Effects Of Tree Evapotranspiration And Canopy Interception In Stormwater Management Systems And Strategies: A Review Of Current Literature And Proposed Methodology For Quantification In The MIDS Calculator Application” Produced by The Kestrel Design Group Team for Objective 1, Task 13 for literature review on evapotranspiration and interception

Lindsey, P., and N. Bassuk. "Specifying soil volumes to meet the water needs of mature urban street trees and trees in containers." *Journal of Arboriculture* 17, no. 6 (1991): 141-149.

Saxton, K. E.  and W. J. Rawls. 2006. Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions. Soil Science Society of America Journal Vol. 70 No. 5, p. 1569-1578.

Scurlock, J.M. O., G. P. Asner, and S. T. Gower. *Global Leaf Area Index from Field Measurements, 1932-2000. Data set.* Prod. Oak Ridge National Laboratory Distributed Active Archive Center. Oak Ridge, Tennessee: Oak Ridge National Laboratory, June 26, 2002.